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Highlights

- Adolescents with higher TV viewing and sitting time were more likely to present insomnia. Moreover, a lower TV viewing (<1h) was also a risk factor for insomnia.
- A higher physical activity was a protective factor for insomnia, especially among boys
- More than 4h of TV watching was a risk factor for insomnia even among physically active adolescents.

Psychiatry Research

ORIGINAL RESEARCH ARTICLE

Associations between TV viewing, sitting time, physical activity and insomnia among 100,839 Brazilian adolescents

Running title: TV viewing, sitting time, physical activity and insomnia

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Abstract

Our aim was to examine the relationship between insomnia and levels of physical activity (PA) and time spent sitting and TV viewing among Brazilian adolescents. Data from the Brazilian Scholar Health Survey, a nationally representative survey of 9th grade adolescents [mean: 14.28 years (range: 11-18 years)] conducted in 2015 (n=100,839) were used. Self-reported insomnia, TV viewing, sitting time and total PA (adapted International PA Questionnaire) were collected. Chronological age, race, type of city (capital or interior) country region, goodies ingestion and ultra-processed foods ingestion were covariates. Logistic regression analyses were conducted to assess the associations. A higher sitting time and TV viewing (≥8h/day) was associated with a higher risk of insomnia among boys [sitting time: OR=2.39 (95%CI=1.88-3.04); TV:OR=2.49(95%CI=1.92-3.22) and girls [sitting time: OR=2.17(95%CI=1.84-2.57; TV:OR=1.72(95%CI=1.44-2.04)]. More than 4 hours of sitting time per day was associated with higher risk of insomnia in adolescents who comply [boys: OR=1.43(95%CI=1.19-1.73); girls: OR=1.66(95%CI=1.41-1.94)] and who do not comply with the 300 min/week of physical activity recommendation [boys= OR=1.35(95%CI=1.13-1.60); girls: OR=1.38(95%CI=1.20-1.57)]. Our data suggest that higher levels of TV viewing or sitting are associated with sleep difficulties in this large cohort of adolescents, irrespective of their physical activity behavior.

Key words: physical activity; sedentary lifestyle; mental health; depression; youth

1. Introduction

Insufficient sleep and sleepiness are serious public health concern in adolescents (Owens, 2014). Insomnia disorder is the most severe clinical manifestation of recurrent and chronic perceived sleep dissatisfaction (i.e. difficultly falling asleep and staying asleep despite having an adequate opportunity to sleep) (American Psychiatric Association, 2013). It occurs several times per week during several months and results in significant daytime distress, difficulties with attention, concentration and memory, and mood lability. The prevalence of insomnia in adolescence ranges between 4% and 39% depending on the diagnostic criteria used (De Zambotti et al., 2017). Insomnia is frequently comorbid with other mental conditions, with half of adolescents with insomnia also reporting comorbid psychiatric disorders (Johnson et al., 2006). Through direct and indirect relationships (via substance use, mood and anxiety disorders) insomnia is furthermore associated with suicidal behaviour (Wong et al., 2016). Next to potential severe psychiatric consequences, lack of sleep among adolescents is also associated with higher cardio-metabolic risks (Countryman et al., 2013). Adolescent girls are at a higher risk after the onset of menarche, suggesting that hormonal changes underlying puberty may be directly or indirectly involved (Johnson et al., 2006). Previously reported potentially modifiable risk factors of insomnia among adolescents include electronic media use (Lange et al., 2017), school stress (Roberts et al., 2008), and the consumption of highly caffeinated beverages (Koivusilta et al., 2016; Owens et al., 2014).

There are two main approaches for the treatment of insomnia in adolescence, i.e. cognitive behavioral therapy and pharmacotherapy. Both approaches can be used in isolation or combination. Cognitive behavioral techniques include arousal reduction (quieting pre-bedtime activities and relaxation-imagery), improving sleep hygiene practices (increase behaviors and environmental conditions that promote improved sleep quality), stimulus control (adopt regular schedules, consolidate sleep to night-time, and improve bed-sleep association), and sleep restriction (temporarily limit hours in bed to increase sleep efficiency) (Zhou and Owens, 2016). Most used medication to treat insomnia are benzodiazepines, melatonin, pyrimidine derivatives (e.g., zolpidem), a-receptor agonists (e.g., clonidine), sedating antihistamines (e.g., hydroxyzine) and sedating antidepressants (e.g., trazodone) (Owens et al., 2005). Pharmacotherapy might however have side-effects while a common problem with cognitive

behavioral therapy among adolescents is compliance with the protocol (Bootzin and Stevens, 2005).

Given the prevalence and burden of insomnia in adolescence, it is essential to understand all modifiable risk factors so that comprehensive and targeted interventions can be designed for this population. Next to limiting electronic media use, coping with school stress, and limiting the consumption of highly caffeinated beverages, promoting physical activity and limiting sedentary behavior might be promising. For example, research shows that 30 minutes of running in the morning during weekdays for three consecutive weeks impacted positively on sleep and psychological functioning in healthy adolescents compared with a control group (Kalak et al., 2012). However, the relationship between physical activity, sedentary behavior and insomnia is complex and poorly understood. While on one hand, evidence shows that engaging in physical activity can alleviate or prevent sleep problems among adolescents (Lang et al., 2016), on the other hand, insomnia can lead to disengagement in physical activity and increased engagement in sedentary behaviors (Brunetti et al., 2016).

Despite some recent advancement in understanding the complex relationships, studies examining associations between physical activity, sedentary behavior and insomnia among adolescents in the low-and-middle-income countries (LMICs) are scarce. In the only nation-wide study to date, screen time among adolescents from Iran was higher in those with insomnia (Mozafarian et al., 2017). Second, it remains to be explored in more detail how much time spent sitting and how much time spent watching TV are associated with insomnia and how much time spent physically active might be protective. Third, more research exploring context specific sedentary behavior such as TV viewing is needed, so as to. provide important insights into the underlying relationships between sedentary behavior and insomnia. For example, previous research among adults in a high income setting demonstrated that mainly passive sedentary behavior (TV viewing) is related with adverse mental health outcomes, while more cognitive challenging sedentary behaviors such as reading, and computer and internet use are to a lesser extent associated with depressive symptoms (Hamer and Stamatakis, 2014). These data however still need to be confirmed in adolescents. Exploring associations between the presence of insomnia and sedentary behavior in LMICs is of particular importance given different socio-

cultural structures, methods of transportation, and environmental factors (e.g., safety, climate) compared with high income countries (Arat and Wong, 2017).

The continuing dearth of studies from this part of the world also highlights the gap between where research is conducted and where the largest public health impacts of physical inactivity will occur (Sallis et al., 2016). However, given that sleep problems have been highlighted as a growing problem in LMICs (Koyanagi et al., 2018; Peltzer and Pengpid, 2017; Stranges et al., 2012) and that interaction between factors that result in insomnia tend to vary according to social and cultural conditions, information from nationally representative samples in LMICs is warranted. Therefore, the present study examined the relationship between insomnia and levels of physical activity, and time spent sitting and time spent TV viewing in a representative sample of Brazilian adolescents. A second aim was to investigate the interaction effect of being physically active and TV viewing on insomnia.

2. **Methods**

2.1. Sample and procedure

Data from the current study were derived from the Brazilian Scholar Health Survey (PeNSE in Portuguese). PeNSE was conducted in 2015 with the goal to investigate the risk/protective factors related to health in adolescents from public and private schools in Brazil (IBGE, 2015). The survey included a representative sample of students from the final (9^{th}) year of elementary education, which was selected using a complex multi-stage, stratified, clustered probability design.

The sampling process and methods are detailed elsewhere (IBGE, 2015). Briefly, the cluster sampling was performed in two stages in capital cities (with schools as primary units and classes as secondary units) and three stages in other municipalities (with municipalities as primary units, schools as secondary units and classes as tertiary units). The proportion utilized for type of school (public or private) was based on the proportion of the total population enrolled in each type of school, which was also included in the estimation of sampling weights. From 3,160 eligible schools, a sample of 3,040 schools, with 124,227 students was eligible to be included in the survey. Of these students, only 102,301 accepted to participate or were at school on the days of interview. Due to missing data, the current analyses considered data from 100,839 students for general analyses and 100,595 students for analyses including dietary patterns at 3,040 schools.

Data were collected by self-administered questionnaires, which consisted of two sections. The first, which focused on the contextual characteristics of the school, was answered by the school director/coordinator with questions concerning the school and what the school offers (e.g. number of enrolled students; if the school offers sports after classes; structure of the school's sports and study facilities; what is on sale in the school canteen). The second section was self-administered by the students and covered individual characteristics and information on physical activity and sedentary behavior. All procedures were approved by the Research Ethics National Council of the National Health Council, and the study was conducted in accordance with the principles expressed in the Declaration of Helsinki (CONEP n. 1.006.467).

2.2. Insomnia

Insomnia was assessed with the following question: "*Considering the last 12 months, how frequently do you have insomnia due to any concern? A) Never; B) Rarely; C) Sometimes; D) Frequently; E) Very frequently."* Adolescents who reported frequently and very frequently were classified as having insomnia.

2.3. Physical activity and sedentary behavior

Physical activity and sitting time were self-reported using an adaptation of the long version of the International Physical Activity Questionnaire (IPAQ). The questionnaire was modified to be specific to adolescents. The occupation domain section was changed to questions asking about physical education classes, and specific questions focusing on transportation to school. Also, questions regarding after school exercise/sports practice were included. This modified instrument has been shown to be valid and reliable in Brazilian adolescents (Tavares et al., 2014). Total physical activity was calculated as weekly minutes (min/week) of physical activity scores across the different domains (active transport, leisure physical activity and physical education classes). The participants were also asked about their total time watching television (TV) per day and total time spent sitting or in reclining position. For the analysis of the interaction between TV viewing and physical activity, we adopted the international cut points of $\geq$2h/day of TV viewing and <420 min/week of physical activity as risks of not complying with sedentary behavior and physical activity guidelines (American Academy of Pediatrics. Committee on Public Education, 2001; World Health Organization, 2010). Moreover, because prevalence of TV viewing is very high and that of physical activity is low and <2h/day may not sufficiently discriminate risks in Brazilian adolescents (Coledam et al., 2014; Guerra et al., 2016), we adopted an alternative cut point of $\geq$4h/day of TV viewing and <300 min/week of physical activity as risk of not complying with sedentary behavior and physical activity guidelines

2.4. Covariates

Chronological age and race were self-reported by participants; race was classified as white and non-white in our study. Information on country regions (north, northeast, southeast, south and Midwest) and type of city (capital or interior) was also collected as covariate. Goodies

consumption was assessed through the question: *"Considering the last week, how many days did you eat goodies? (sweets, candies, chocolate and others)*". Response options were categorized as: 0 times, 1-3 times and more than 4 times. Ultra-processed food consumption was assessed through the question: *"Considering the last week, how many days did you eat industrialized/ultra-processed food as hamburger, ham, mortadella, salami, sausage, sausage, instant noodles, packet salt, crackers, salty and others?*", and response categorized into the following groups: 0 times, 1-3 times and more than 4 times.

2.5. Statistical analysis

For descriptive analyses, the values of frequencies as well as 95% confidence intervals (95%CI) were computed. Chi-square tests were used for difference between sexes. Logistic regression analyses, with odds ratio (CI95%) adjusted for chronological age, race, type of city (capital or interior), country regions, physical activity/sitting time, goodies ingestion and ultra-processed foods ingestion were conducted for the main analysis of association between physical activity, sitting time, TV viewing and insomnia among adolescents. All analyses were conducted using sampling weights (svy command) in STATA 15.0, adopting $p<0.05$.

3. Results

In total, 100,839 adolescents were included in the final sample and 100,595 for analyses including dietary patterns. The mean age of the sample was 14.28 years (range: 11y to 18y) and about 51% of them were girls. Characteristics of sample are described in **Table 1.** Prevalence of insomnia due to concerns was greater among girls when compared to boys [boys: 6.9% (6.5% to 7.3%) vs. girls: 15.5% (14.9% to 16.0%); p<0.001]. Higher physical activity levels and lower sitting time and TV viewing were observed among boys than in girls (p<0.001).

Insert Table 1 about here

Prevalence of insomnia according to sitting time and TV viewing patterns is described in **Figure 1**. Adolescents who spent more time sitting and TV viewing were at higher risk for insomnia due to concerns, also confirmed through the logistic regressions of **Table 2,** given that adolescents who spent more than 8h/day in sitting positions were 139% (boys) and 117% (girls) more likely to present insomnia due to concerns. Also, boys and girls who watch TV more than 8h/day had respectively 149% and 72% more chance to present insomnia due to concerns, when compared to adolescents who reported between 2.01h/day and 3h/day of sitting time/TV viewing (group of lower insomnia's prevalence). Adolescents who watched less than one hour of TV per day also presented a greater prevalence of insomnia [boys: 7.8% (7.1% to 8.7%); girls: 17.1% (15.9% to 18.3%)], as well as a higher likelihood of insomnia independent from other confounders [boys: OR= 1.66 (95%CI= 1.33 to 2.08). Girls: OR= 1.42 (95%CI= 1.22 to 1.66).

Insert Figure 1 about here

Insert Table 2 about here

Figure 2 presents the prevalence of insomnia according to physical activity patterns. Higher physical activity levels were only associated with a lower prevalence of insomnia in boys. An amount of at least 60 minutes of physical activity per week was increasingly associated with

less insomnia until 179 minutes per week. Between 180 minutes and 419 minutes per week the lower risk remains the same for boys and girls, while more than 420 minutes of physical activity per week increases the risk among girls ($p<0.001$), but with no significant difference from the group of 0min/week of physical activity in the adjusted analyses ($p>0.05$).

The co-occurrence of physical activity participation and sitting time in predicting insomnia is presented in **Figure 3**. More than 4 hours of sitting time per day was associated with higher risk for insomnia in boys and girls who comply [boys: OR=1.43(95%CI=1.19-1.73); girls: OR=1.66(95%CI=1.41-1.94)] and who do not comply with the 300 min/week of physical activity recommendation [boys= OR=1.35(95%CI=1.13-1.60); girls: OR=1.38(95%CI=1.20-1.57)].

Insert Figure 2 about here

Insert Figure 3 about here

4. Discussion

Our study aimed to evaluate the association between physical activity, TV viewing, total sitting time and insomnia in a representative sample of Brazilian adolescents. We show that more time spent sitting and viewing TV and less time spent physically active were associated with more insomnia. More than 4 hours of sitting time per day was associated with the highest risk irrespective of physical activity levels. There were some differences between boys and girls. Especially among girls, the highest levels of physical activity (more than 420minutes per week) were associated with a higher risk for insomnia.

The most consistent finding was that more time spent watching TV is associated with more insomnia. This way, our study from a middle-income country supports previous findings from high-income countries (Hale and Guan, 2015) showing that television watching is associated with significantly delayed bedtime or shortened total sleep time in adolescents.

Of interest and different with findings from high income countries was that less than 1 hour of TV viewing was also associated with a higher risk for insomnia. One hypothesis is that no or very limited time spent viewing TV might be a measure-of-proxy for a lower socioeconomic status (not having a TV at home), which is a known risk factor for insomnia in adolescents (von Soest et al., 2012). Physical activity was associated with less insomnia among boys. While in girls, moderate levels of physical activity were associated with less insomnia but high levels (above 420 minutes per week) were related to more insomnia. These results corroborate previous findings of European adolescents (McMahon et al., 2017), which found a dose-response association between physical activity and negative mental health outcomes among boys and a curvilinear association among girls. It might be that a subgroup of girls reporting very high levels of daily physical activity include adolescents who over-exercise and suffer from eating disorders or other psychopathology (Smith et al., 2013), which is associated with insomnia.

There are likely psycho-social and biological mechanisms underlying the protective effect of physical activity on insomnia risk in boys and girls who don't over-exercise. Physical activity may improve mental health by enhancing monoamine levels through increased neurotransmitter activity and increased levels of endorphins or moderate activation of the limbic system and reduce levels of cortisol secretion (Alghadir et al., 2016; Rethorst et al., 2011).

Improved mental health is associated with less insomnia. Other proposed mechanisms include body temperature changes, cytokine concentration changes, changes in heart rate and heart rate variability, growth hormone secretion, brain derived neurotropic factor secretion, improved fitness levels and body composition changes (Kredlow et al., 2015).

Our data cannot provide a causal inference about the associations between higher sedentary levels and more insomnia. However, some previous studies can provide some indications of a potentially causal relationship, which will underpin our assertions. For instance, previous research from randomized controlled trials in Western samples has demonstrated the independent deleterious impact of increasing sedentary behavior on mood and in particular symptoms of anxiety in active youth (Edwards and Loprinzi, 2016), possibly through changes in inflammation (Endrighi et al., 2016). Previous research has also suggested that sedentary behavior is associated with inflammation, most notably c-reactive protein and interleukin 6 (Henson et al., 2013). There is some provisional evidence in adults to suggest that standing and breaking up prolonged periods of sedentary behavior can improve inflammatory biomarkers profiles (Healy et al., 2011), while in adolescents metabolic benefits were observed (Fletcher et al., 2017). In addition, children and adolescents may be more vulnerable to physiological responses from arousal of the central nervous system and associated negative effects on sleep patterns with high rates of TV viewing (Hamer et al., 2009; Hume et al., 2011).

The findings of the present study should however be considered with caution. First of all, the design of this study was cross-sectional, and causality cannot be inferred. Adolescents with higher reported levels of insomnia may choose to be less physically active because they are experiencing fatigue and volition during waking hours and consequently prefer to be more involved in socially isolated activities such as TV viewing and other sedentary activities. The other way around being less physically active and watching more TV may act to increase insomnia risk. More comprehensive longitudinal studies are needed to better understand the complex and potentially reciprocal relationship between these variables. Second, potential confounders such as the socio-economic status and symptoms of depression and anxiety were not controlled for in the analyses. On the other hand, we presented data on combined physical activity and sedentary behaviors from a large national representative sample of adolescents from a developing country, providing new insight from an understudied population.

Future interventions based on the current findings may consider investigating the potential benefits of replacing cognitive passive solitary sedentary behaviors such as watching TV with cognitive more active sedentary behaviors such as reading or spending time with friends. Types of intervention to reduce total sitting time that should be explored in a low income setting is sitting-standing workplaces in classrooms, which have been shown to decrease sedentary behavior without impact on learning in Western settings (Clemes et al., 2016; Erwin et al., 2017).

In conclusion, a higher sitting time and a lower physical activity were associated with a greater prevalence of insomnia among adolescents in Brazil. Similarly, a higher TV viewing was also associated with a greater prevalence of insomnia, but a lower TV viewing (<1h) was related to a greater prevalence of insomnia and 3-4h seems to be a threshold for an increased insomnia risk. Moreover, more than 4 hours of sitting time per day was associated with the highest risk irrespective of physical activity levels. Finally, more than 420 min/week was related to insomnia only among girls. Although further evidence is needed, interventions focusing on reducing time spent in TV viewing and sitting may be relevant for controlling and preventing sleep difficulties among Brazilian adolescents.

Compliance with ethical standards

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest: The authors declare that they have no conflicts of interest.

Ethics approval: All procedures performed in the original studies involving human participants were approved by national council of ethics in research (CONEP: 10853812.7.0000.0008) in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

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Figure legends:

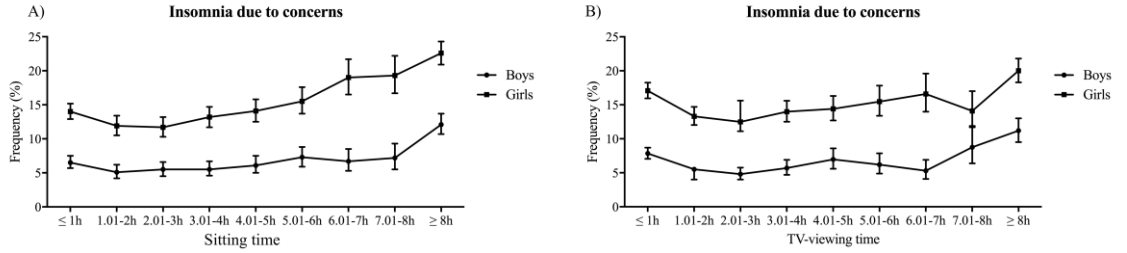

Figure 1. Prevalence of insomnia according to sitting time (A) and TV viewing (B) patterns.

Note. TV, television.

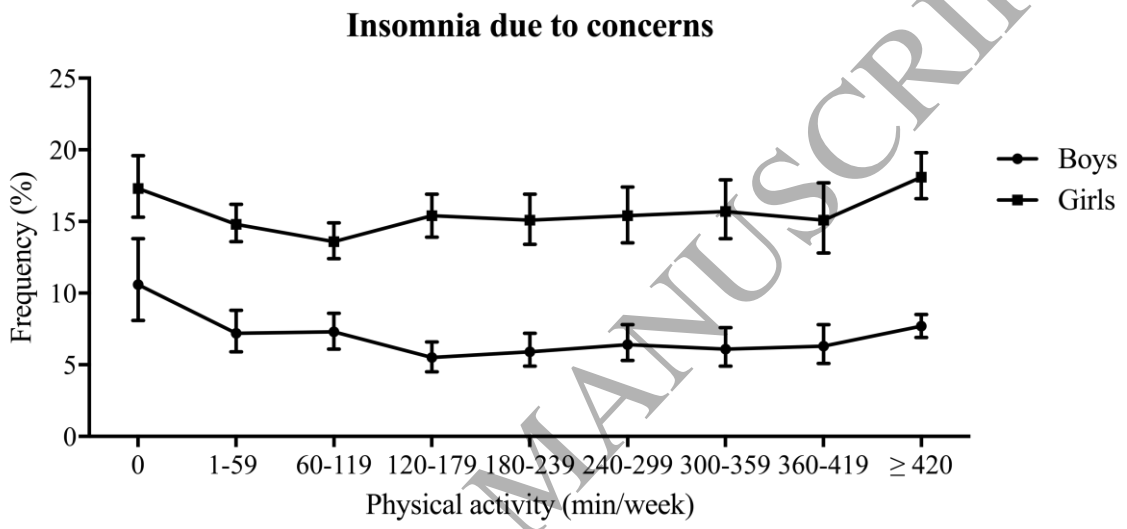

Figure 2. Prevalence of insomnia according to physical activity patterns.

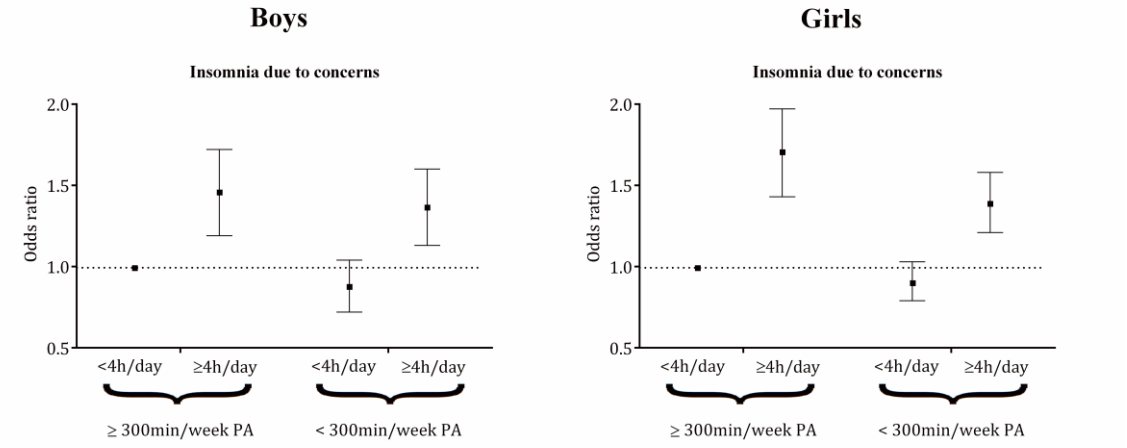

Figure 3. Association between physical activity, sitting time and insomnia due to concerns.

Note. <4h/day and ≥4h/day represents TV viewing. Adjusted for age group, race, country region, type of city (capital or interior), physical activity/sitting time, goodies ingestion and ultra-processed foods ingestion. OR, odds ratio. CI, confidence interval.

Table 1. Characteristics of the sample according to sex.

	N	Male % (IC 95%)	n	Female % (IC 95%)
Age				
<14 years	7,084	16.1 (15.4 to 16.7)	10,019	20.4 (19.8 to 21.1)
14 years	23,428	48.8 (48.0 to 49.6)	27,651	53.3 (52.5 to 54.0)
>14 years	18,047	35.1 (34.4 to 35.8)	14,610	26.3 (25.7 to 26.9)
Country region				
North	11,531	9.5 (9.3 to 9.8)	12,080	9.6 (9.3 to 9.9)
Northeast	16,727	26.3 (25.8 to 26.9)	19,196	29.0 (28.5 to 29.6)
Southeast	8,601	44.4 (43.6 to 45.3)	8,982	42.4 (41.6 to 43.2)
South	4,804	12.1 (11.7 to 12.5)	4,935	11.6 (11.2 to 12.1)

Midwest	6,896	7.6 (7.4 to 7.8)	7,087	7.3 (7.1 to 7.5)
Type of city				
Capital	24,511	23.2 (22.7 to 23.7)	26,098	22.8 (22.3 to 23.3)
Non-capital	24,048	76.8 (76.2 to 77.3)	26,182	77.2 (76.7 to 77.7)
Skin color				
White	18,635	41.1 (40.3 to 41.9)	19,340	39.6 (38.9 to 40.0)
Other	29,924	58.9 (58.1 to 59.7)	32,940	60.4 (59.6 to 61.1)
Goodies consumption				
0 times	6,764	13.1 (12.6 to 13.7)	4,733	8.3 (7.9 to 8.7)
1-3 times	20,537	41.1 (40.4 to 42.0)	18,879	35.1 (34.4 to 35.8)
≥ 4 times	21,116	45.7 (44.9 to 46.5)	28,568	56.6 (55.9 to 57.4)
Ultra-processed foods consumption				
0 times	8,008	15.7 (15.2 to 16.3)	7,831	13.9 (13.4 to 14.4)
1-3 times	20,965	44.2 (43.4 to 45.0)	21,808	42.4 (41.7 to 43.2)
≥ 4 times	19,444	40.1 (39.3 to 40.9)	22,541	43.6 (42.9 to 44.4)
Insomnia due to concerns				
No	45,121	93.1 (92.7 to 93.5)	44,095	84.5 (84.0 to 85.1)
Yes	3,438	6.9 (6.5 to 7.3)	8,185	15.5 (14.9 to 16.0)
Total PA				
0 min	1,610	2.8 (2.6 to 3.1)	3,879	6.6 (6.2 to 7.0)
1-59 min	4,756	9.8 (9.3 to 10.3)	9,173	17.3 (16.7 to 17.9)
60-119 min	5,693	11.7 (11.2 to 12.3)	8,498	16.8 (16.2 to 17.4)
120-179 min	5,857	12.5 (12.0 to 13.10	7,539	14.8 (14.3 to 15.4)
180-239 min	5,046	10.3 (9.8 to 10.7)	5,456	10.8 (10.3 to 11.3)
240-299 min	4,576	9.6 (9.1 to 10.1)	4,571	8.9 (8.5 to 9.4)
300-359 min	3,928	8.0 (7.5 to 8.4)	3,462	6.3 (5.9 to 6.6)
360-419 min	3,458	7.4 (7.0 to 7.8)	2,657	5.3 (4.9 to 5.6)
≥ 420 min	13,635	27.9 (27.2 to 28.6)	7,045	13.2 (12.7 to 13.8)
TV view				
< 1h	13,005	25.8 (25.1 to 26.5)	13,629	24.5 (23.8 to 25.1)
1-1.99h	7,806	16.0 (15.4 to 16.6)	7,691	14.1 (13.6 to 14.6)
2-2.99h	7,000	13.6 (13.0 to 14.1)	6,697	13.0 (12.4 to 13.5)
3-3.99h	5,874	12.8 (12.2 to 13.3)	6,066	11.6 (11.1 to 12.1)
4-4.99h	4,174	8.8 (8.4 to 9.3)	4,543	8.8 (8.4 to 9.3)
5-5.99h	3,076	6.7 (6.3 to 7.1)	3,578	7.4 (7.0 to 7.8)
6-6.99h	1,738	3.6 (3.3 o 3.9)	2,130	4.2 (3.9 to 4.5)
7-7.99h	1,404	3.0 (2.7 to 3.3)	2,080	4.3 (4.0 to 4.6)
≥ 8h	4,482	9.8 (9.3 to 10.3)	5,866	12.3 (11.8 to 12.8)
Sitting time				
< 1h	9,854	20.0 (19.4 to 20.6)	10,335	18.7 (18.2 to 19.3)
1-1.99h	6,249	12.6 (12.1 to 13.2)	6,539	12.2 (11.7 to 12.7)
2-2.99h	6,333	12.8 (12.3 to 13.4)	6,138	11.4 (10.9 to 11.9)
3-3.99h	6,113	12.1 (11.6 to 12.7)	6,096	11.7 (11.2 to 12.2)
4-4.99h	5,211	10.7 (10.2 to 11.2)	5,193	9.6 (9.1 to 10.0)
5-5.99h	4,165	9.2 (8.7 to 9.6)	4,469	9.0 (8.5 to 9.5)
6-6.99h	2,749	5.8 (5.5 to 6.2)	3,176	6.5 (6.1 to 7.0)
7-7.99h	1,926	3.9 (3.6 to 4.3)	2,710	5.4 (5.1 to 5.8)
≥ 8h	5,959	12.8 (12.2 to 13.3)	7,624	15.4 (14.8 to 16.0)

Note. CI, confidence interval; PA, physical activity; TV, television

Table 2. Association between sitting time, TV viewing, physical activity and insomnia due to concerns.

	Sex	
	Boys OR (CI 95%)	**Girls OR (CI 95%)**
Sitting time (per day)		
< 1h	1.19 (0.93 to 1.52)	1.19 (1.01 to 1.41)
1-1.99h	0.93 (0.70 to 1.24)	1.00 (0.82 to 1.22)
2-2.99h	1	1
3-3.9h	1.02 (0.77 to 1.34)	1.14 (0.95 to 1.38)
4-4.99h	1.12 (0.84 to 1.50)	**1.24 (1.02 to 1.50)**

5-5.99h	**1.36 (1.02 to 1.81)**	**1.39 (1.14 to 1.70)**
6-6.99h	1.23 (0.89 to 1.69)	**1.78 (1.43 to 2.22)**
7-.7.99h	1.33 (0.95 to 1.86)	**1.79 (1.43 to 2.24)**
≥8h	**2.39 (1.88 to 3.04)**	**2.17 (1.84 to 2.57)**
TV viewing (per day)		
< 1h	**1.66 (1.33 to 2.08)**	**1.42 (1.22 to 1.66)**
1-1.99h	1.16 (0.90 to 1.50)	1.07 (0.90 to 1.27)
2-2.99h	1	1
3-3.9h	1.20 (0.91 to 1.59)	1.13 (0.94 to 1.36)
4-4.99h	**1.48 (1.10 to 2.00)**	1.17 (0.96 to 1.42)
5-5.99h	1.30 (0.95 to 1.78)	**1.27 (1.02 to 1.57)**
6-6.99h	1.11 (0.79 to 1.56)	**1.37 (1.07 to 1.74)**
7-.799h	**1.87 (1.26 to 2.78)**	1.11 (0.86 to 1.44)
≥8h	**2.49 (1.92 to 3.22)**	**1.72 (1.44 to 2.04)**
Physical activity (per week)		
0 min	1	1
<60 min	**0.68 (0.46 to 0.99)**	0.87 (0.72 to 1.05)
60-119 min	**0.67 (0.47 to 0.96)**	**0.79 (0.65 to 0.95)**
120-179 min	**0.53 (0.36 to 0.76)**	0.86 (0.71 to 1.04)
180-239 min	**0.51 (0.35 to 0.74)**	0.85 (0.69 to 1.04)
240-299 min	**0.55 (0.37 to 0.80)**	0.88 (0.71 to 1.10)
300-359 min	**0.60 (0.41 to 0.88)**	0.93 (0.76 to 1.15)
360-419 min	**0.57 (0.39 to 0.83)**	0.88 (0.69 to 1.12)
≥420 min	**0.72 (0.52 to 0.99)**	1.06 (0.88 to 1.27)

Note. Analysis adjusted for age group, race, country region, type of city (capital or interior), physical activity/sitting time, goodies ingestion and ultra-processed foods ingestion. OR, odds ratio. CI, confidence interval.